B. CAPABILITIES ASSESSMENT

1. Mission Capabilities - The geographical location of Vandenberg AFB makes it ideal for a variety of missions. Launch azimuths for various vehicles (ballistic and space) launched from Vandenberg have ranged from approximately 147^0 to 313^0. See **Figure 8**$_4$ for WTR allowable launch corridors.

Unique among WSMC's capabilities is the capacity to launch spacecraft into a polar orbit without over-flying any land mass until reaching Antarctica. On these southerly launches, WSMC's up-range sensors may be augmented by sensors of the Navy's Pacific Missile Test Center (PMTC). To provide coverage farther south, beyond the range of land-based sensors, the Advanced Range Instrumentation Aircraft (ARIA) of the 4950th Test Wing, Wright Patterson Air Force Base, Ohio, may be used. These resources (the Navy at PMTC and ARIA) can also provide coverage for ballistic launches into the Kwajalein Missile Range and Pacific broad ocean areas as well as other launches on a westerly azimuth. In addition, the Observation Island, a range instrumented ship, also supports some of the ballistic tests. WSMC also maintains a communications control center and high frequency transmitters on Oahu, while the high frequency receivers are located on Molokai. WSMC facilities can be supplemented by additional telemetry, metric and optic sensors operated by the Navy and other Air Force organizations.

2. Instrumentation Capabilities - WSMC's range instrumentation systems acquire and record test data consistent with users' requirements.

Instrumentation required for tests on the WTR is controlled and operated by WSMC personnel with the exception of Range User test vehicle airborne equipment and certain user associated ground equipment. Also, all camera sites on VAFB except LA24 are operated by SAC.

Program support requiring frequency control and analysis, optical coverage, instrumentation checkout and other special services can be provided through WSMC. See **Figure 2**$_5$ for the various locations of WTR instrumentation.

The WSMC data centers form the central telemetry and metric data processing facilities. The data centers are coupled to the launch complexes, assembly and checkout facilities, acquisition sites, Pillar Point and PMTC via microwave links. In addition, the data centers are linked by microwave to Edwards AFB, California, for real-time transmission of aircraft test data.

Data handling and processing equipment include a full range of data transfer systems and data processing centers for real-time processing and display as well as post-flight processing and telemetry checkout. Other instrumentation systems include surveillance radars, meteorological data collection equipment and command control transmitters.$_{10}$ It is anticipated that the commercial user will define his instrumentation and data requirements when negotiating a memorandum of agreement for launch support with the Range.

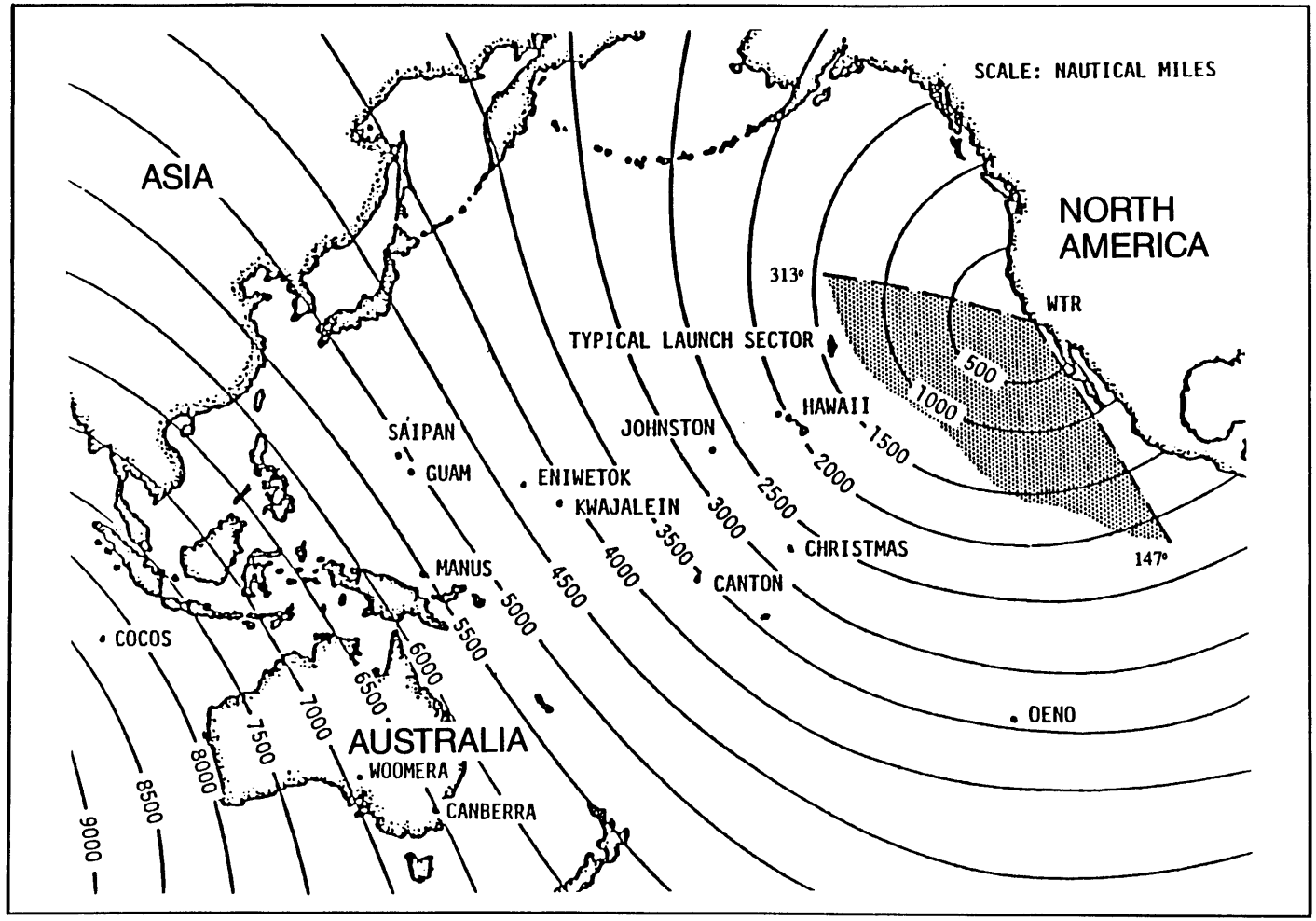

FIGURE 8. WTR ALLOWABLE LAUNCH CORRIDORS

a. Radar Systems - The radar systems are divided into two categories based on capabilities (**See Table 2** for radar capabilities). The Missile Precision Instrumentation (MIPIR) class radars (AN/TPQ-18, AN/FPQ-6, High Accuracy Instrumentation Radar (HAIR) and AN/FPS-14) use 29-foot diameter antennas and three (plus) megawatt transmitters to provide longer track range and smaller target detection. The AN/FPS-16 class radars (AN/FPS-16-1,-2 and AN/MPS-36) use 12-foot antennas and 1 megawatt transmitters to provide high precision track, but at closer ranges.[9]

(1) General - The WTR radar network provides information concerning real-time vehicle position and impact prediction for use by Range Safety. The WSMCR 127-1 requires that a tracking aid (radar beacon) be carried on space vehicles, and the beacon mode is used as the primary method for tracking space vehicles.

(2) Limits - The Range Safety radar tracking limits of capability vary by mission and vehicle type. Radar tracking information is provided to Range Safety to satisfy their mission requirements and provide continuous tracking of the vehicle from lift-off through orbital insertion or loss of signal (LOS). Representative Range Safety radar coverage T+ time intervals for past missions conducted at the WTR for the Atlas, Delta, Scout and Titan vehicles are presented in **Table 3**[11].

TABLE 2. RADAR SYSTEMS CAPABILITIES

System	Location	Antenna Diameter	Gain	Beamwidth	Transmitter Power Out	Pulsewidth μs	Frequency Range	Nom. Max. Range	Special Features
AN/TPQ-18	Bldg 907 SVAFB	29 feet	51db	0.4°	3.0MW	.25,.5,1.0 & 2.4	5.4-5.9GHZ	131,000NM	Coherent Signal Processor, Range Vernier, Integrated Range Track, Realtime Event Recording, Opt Trk
AN/FPS-16-1	Bldg 175 SVAFB	12 feet	42db	1.2°	1.0MW	.25,.5,1.0	5.4-5.9GHZ	32,000NM	Radar Embedded Computer, Optical Tracking, Realtime Event
FPS-16-2	Bldg 178 SVAFB	12 feet	42db	1.2°	1.0MW	.25,.5,1.0	5.4-5.9GHZ	131,000NM	Integrated Range Tracker, Optical Tracking, Realtime Event
HAIR	Bldg 1639 NVAFB	29 feet	51db	0.4°	1.0MW 4.0MW	.25,.5,1.0 CMF 12.5	5.4-5.9GHZ	32,000NM	Range Vernier, Digital Velocity Extraction System, Radar Embedded Computer, Harris Imp Feed
AN/FPQ-6	Bldg 7 PPAFS	29 feet	51db	0.4°	3.2MW	.25,.5,1.0 & 2.4	5.4-5.9GHZ	32,000NM	Harris Imp Feed, Radar Embedded Computer, Coherent Signal Processor, Range Vernier, Opt Optical Tracking
AN/MPS-36	PPAFS	12 feet	44db	1.0°	1.0MW	.25,.5,1.0	5.4-5.9GHZ	32,000NM	Radar Embedded Computer, Coherent Signal Processor, Range Vernier, Imp Ant Dish & Feed
AN/FPQ-14	Kaena Point Oahu	29 feet	53.8db	0.4°	4.0MW	CMF,1.0 & 2.4	5.4-5.9GHZ	8182NM	On Axis Tracking, Realtime Event, Tape Recording, Auto Scheduling Computer, WSMC STD Console/ Control System

SVAFB - South Vandenberg Air Force Base
NVAFB - North Vandenberg Air Force Base
PPAFS - Pillar Point Air Force Station

TABLE 3. RADAR COVERAGE CAPABILITIES	
VEHICLE	**COVERAGE(seconds)**
Atlas	0 - 733
Delta	5 - 460
Titan	17 - 463
Scout	5 - 953

b. Telemetry Systems - The WTR telemetry systems acquisition sites process telemetry signals from aircraft, missiles, orbiting satellites and closed loop systems for recording, reformatting, processing or distribution to other areas. They provide data products in real time or on a post operational basis. In addition, the ARIA aircraft are available as mobile stations.[9] The installations operated by the WTR are:

(1) Vandenberg Telemetry Receiving Site (TRS) - The TRS is located approximately 12 miles south of Lompoc, California, on Oak Mountain, SVAFB, and was built on facilities vacated by the former Lompoc Air Defense Command in 1968. The TRS was equipped and activated in 1970-71. Its primary mission is to track targets transmitting telemetry signals and to record and relay received signals. The TRS acquires data from launches of ballistic missiles and earth orbiting satellites, from stationary satellites and from aircraft test flights. Telemetry data are re-transmitted via microwave to the Telemetry Analog Equipment Room (TAER) in the building 7000 complex for distribution, data processing and display.

This site has three receive/record stations, a Space Ground Link Subsystem (SGLS) downlink capability, a telemetry Doppler System and a Tracking and Data Relay Satellite System (TDRSS) uplink/downlink ground station, in addition to various antennas.

(2) Pillar Point Telemetry Station - The Pillar Point Telemetry Station is a prime element in the total WSMC data collection capability. The location of the facility gives near optimum tracking geometry for the reception of high quality telemetry data for ballistic launch operations. This facility is also equipped to support orbital and aircraft test programs. Telemetry data acquired by the Pillar Point facility are recorded on magnetic

tape recorders for post flight decommutation and processing and are also relayed directly to VAFB via a microwave link for real time decommutation and display.

(3) Telemetry Analog Equipment Room (TAER) - TAER provides the capability to receive, record and playback telemetry data. In addition, TAER has the capability to configure the equipment in the room by use of a computerized Analog Data Equipment Switching System (ADESS).

(4) Telemetry Integrated Processing System (TIPS) -Located on VAFB, TIPS is the central telemetry data processing facility. It is coupled to the launch complexes, assembly and checkout facilities, Oak Mountain, Pillar Pt. and PMTC via microwave link.

(5) Limits - The telemetry coverage limits of capability vary as a function of vehicle type and mission trajectories. **Table 4**[11] provides information concerning Range Safety telemetry timecoverages for previously flown missions from the WTR:

TABLE 4. TELEMETRY COVERAGE CAPABILITIES

VEHICLE	COVERAGE (seconds)
Atlas	0 - 750
Delta	0 - 720
Titan	0 - 620
Scout	0 - 950

c. Optical Systems - The Optical instrumentation system consists of tracking telescope sites strategically located for different aspect angles of mission tracking requirements. They furnish engineering sequential data of missile flight characteristics via different optical sensors and provide real time video to the Missile Flight Control Center.[9] The following are available on the WTR for engineering sequential applications:

(1) Short Range Optics - Short range engineering sequential optical capability is provided through Intermediate Focal Length Optical Tracking Systems (IFLOTS) and Cine-Sextant mounts. These mobile units are located as needed at any of the many different sites at VAFB. They are owned, operated and

maintained by SAC, and are scheduled for support by Range Scheduling.

(2) Long Range Optics - WTR has three tracking telescope sites producingvideo cassette data: 1) A 36" mirrored telescope Deployment Mapping Instrument (DMI) at Anderson Peak near Big Sur, California, which provides an excellent side view aspect angle for launches from Vandenberg AFB with a westerly heading, or aircraft weapons tests in the off-shore corridor, 2) a Recording Optical Tracking Instrument (ROTI) at Santa Ynez Peak which has an excellent aspect angle for polar launches and 3) a Large Aperture (24 inch) telescope (LA-24) tracking instrument located at Tranquillon Peak, VAFB, which provides early launch phase video to the MFCC as well as to other selected areas.

Image intensifier systems are installed on the tracking systems at Anderson and Santa Ynez Peaks to provide enhanced powered and post-powered event recordings in low light level black and white video cassettes.

(3) Downrange Optics - Tracking instrumentation support is also available to the WTR from the Navy at Point Mugu and San Nicolas Island, from the Army at their Kwajalein Atoll test site and from the ARPA Maui Observation Station (AMOS) on Maui, Hawaiian Islands.

(4) Limits - The optical tracking capabilities vary and are dependent on vehicle types, mission trajectories and weather. **Table 5**[11] shows examples of optical coverage in T+ time intervals for past WTR missions:

TABLE 5. OPTICAL COVERAGE CAPABILITIES

VEHICLE	COVERAGE (seconds)
Atlas	~14 - 320
Delta	~25 - 370
Titan	~26 - 490
Scout	~02 - 210

d. Flight Termination System - In order to protect the public, each vehicle (with the exception of weather rockets) proposed for launch on

the WTR is required to carry an airborne Flight Termination System (FTS) which is compatible with the ground system and is capable of terminating thrust of the vehicle and dispersing propellants with minimal explosive effects.

(1) Ground Transmitters and Antennas - The ground transmitting system at WSMC has five active Command Control Transmitter (CCT) sites. Of these five sites, three are located on VAFB (site 1, site 2 and site 3) with both fixed omnidirectional and steerable directional antennas. The other two are remote sites with steerable directional antennas only.

Site 4 is located at Pillar Point and Site 6 is located at Laguna Peak near Point Mugu US Naval Air Station. Site 6 is operated by the PMTC but it can be controlled by WSMC. These sites are all remotely controlled by the operator of the Central Command Transmitter Console (CCTC) located in the Missile Flight Control Center within the Range Operations Control Center at VAFB. The CCTC provides the Range Safety Officer (RSO) with a command transmitter site in proper configuration at all times.[9]

At lift-off, support is provided by one of the Vandenberg-located sites in the omnidirectional antenna configuration. At some predetermined time, the antenna configuration is automatically changed from the omnidirectional to the steerable antenna. At some later predetermined time, the local site is deactivated and one of the remote sites is activated to provide a better look angle for improved RF illumination. Protection against spurious signals influencing the flight termination system is provided by operating the system at power levels which saturate the receivers, not allowing another transmitter site to be located within a 50 mile radius and constant frequency monitoring during launch operations.

The Pillar Point site is used primarily for westerly ballistic launches and the Laguna Peak site for southerly orbital launches. Each site is configured with redundant 10 KW transmitters. A station guardian system automatically switches from the prime to the standby transmitter if a condition of high reflected power or low incident power occurs. See **Figure 9**[9] for a block diagram of a typical ground transmitter system configuration. The system is designed so that no single point failure will cause the transmission of an undesired flight termination command or prevent the Range Safety Officer from initiating the transmission of a flight termination command.

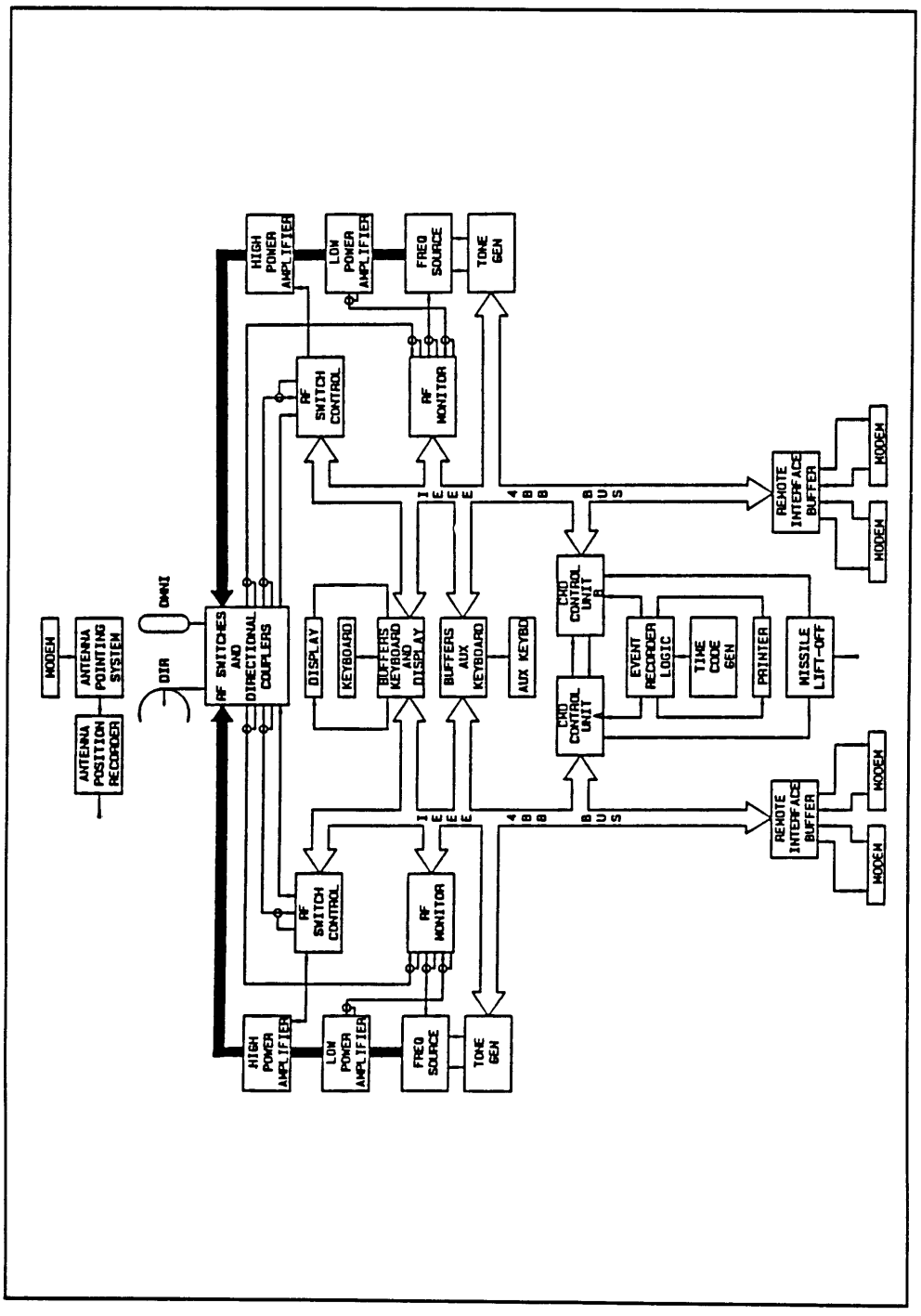

FIGURE 9. TYPICAL COMMAND TRANSMITTER SITE CONFIGURATION

(2) Launch Vehicle FTS Configuration - The airborne portion of the Flight Termination System usually consists of two antennas spaced 180 degrees apart on the vehicle, an antenna coupler, two receivers, two independent power supplies, a single, dual-channel Safe and Arm (S/A) device and the explosive ordnance required to accomplish the required destruct action. Normally, the command system is located on the last or uppermost stage with an Inadvertent Separation Destruct System (ISDS) located on each preceding stage which is designed to function at premature separation of the stages or breakup of the missile. Destruct S&A devices are "armed" electrically just prior to lift-off, except in the case of the Delta vehicle when the S&A's are "armed" by lanyards at lift-off.[8]

(3) FTS System Operation - The standard flight termination scheme is to frequency modulate the carrier with three audio tones to effect "ARM" (fuel cut-off/shutdown for liquid propellant engines) and "DESTRUCT". The audio tones are standard at all ranges and were established by the Inter Range Instrumentation Group (IRIG). Normally, tones 1 and 5 are transmitted as the "ARM" command. This cuts off thrust to a liquid fueled booster and conditions the airborne receiver logic to receive and act upon a "DESTRUCT" command. "DESTRUCT" will not be acted upon unless preceded by "ARM". Tone 1 is kept on, tone 5 removed and tone 2 added to effect "DESTRUCT". This scheme is used, with some minor variations, on all presently active missile systems, except Titan II and IV, being launched from the Range.[8]

(4) Secure FTS - The Space Shuttle uses a secure FTS. This is a digital system which uses seven non-IRIG tones in two-tone combinations to form a message of eleven two-tone characters. Separate messages for "ARM" and "DESTRUCT" are loaded into a microprocessor-equipped airborne receiver and into the ground transmitter encoding equipment. The receiver will recognize only the proper tones transmitted in the proper order and will ignore all other signals. The tone sequence and frequencies used on a particular flight are classified. The Air Force's new generation of Titan vehicles, Titan II and IV, use a secure system similar to the one on the Shuttle, with the same digital message format. In addition, the Air Force version of the Delta will utilize a secure system after the first 3 launches. Further, at some future date (3-5 years), it is planned that all space vehicles may be required to carry a secure FTS in order to launch on a National Range.[8]

(5) Limits - The FTS capabilities provided at the WTR are dependent on the vehicle type and mission trajectories. FTS

coverage is provided until loss of signal or system shutdown (either commanded or automatic).

Table 6[11] depicts representative Range Safety limits for FTS coverages from past WTR missions:

TABLE 6. COMMAND COVERAGE CAPABILITIES

VEHICLE	COVERAGE (seconds)
Atlas	0 - 715
Delta	0 - 670
Titan	0 - 660
Scout	0 - 650